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RECEIVING ANTENNA SYSTEM COMPRISING SEVERAL ACTIVE ANTENNAE

The invention relates to a receiver antenna system with several active antennae.

Between the passive antenna structure and the active electronic elements, such as impedance converters and amplifier elements, active receiver antennae do not have interfaces with a constant surge impedance. In the case of passive antennae, the surge impedance of these interfaces must be adapted in the useful frequency range to the surge impedance of a normal line. This therefore reduces the bandwidth of the receiver antenna system as a whole in an undesirable manner.

If an antenna system is formed from several, active individual antennae, of which the respective electrical antenna height is adapted to the respective received frequency range of the individual antenna, in order to avoid deformed antenna patterns – “peaked antenna patterns” -, a broad-band, overall received-frequency range of the receiver antenna system built up from the several individual receiver-frequency ranges of the individual antennae can be achieved. The shortening of the electrical antenna height of the individual antenna can be implemented electrically by arranging impedance elements, for example, a parallel circuit consisting of an inductance and an ohmic resistor at given heights of the individual antenna. At low received frequencies, the inductance bridges the resistor, while the resistor is active at high received frequencies. It is therefore possible to adjust the electrical antenna height to the respective received frequency range of the individual antenna by an

exact positioning of the impedance elements and a received-frequency-dependent parametrisation of the impedance elements.

A receiver antenna system consisting of several active individual antennae is disclosed in DE 34 37 727 A1. With the disclosed receiver antenna system, the individual antennae are positioned at relatively large spacing distances – up to a few hundred meters – from one another. The mutual electromagnetic couplings of the individual antennae, which impair the directivity, the efficiency and the antenna power gain of the receiver antenna system, are negligible with an arrangement of this kind. However, if a considerably more compact realization of a receiver antenna system is required with spacing distances between the individual antennae in the order of magnitude of a few centimetres, these mutual, electromagnetic couplings of the individual antennae are no longer negligible. In a disadvantageous manner, they lead to deformed antenna patterns of the individual antennae, to a mutual, negative influence on the base-point impedances and to unsymmetrical stresses on the individual antennae, which has the overall effect of impairing the quality of reception of the receiver antenna system.

The invention is therefore based on the object of providing a receiver antenna system with several active individual antennae with a small spacing distance, which provides a broad bandwidth.

This object is achieved by a receiver antenna system according to claim 1. Advantageous embodiments of the invention are specified in the dependent claims.

In order to suppress the above-named, disadvantageous effects, the currents in the individual antennae are decoupled from the electromagnetic couplings by the individual current-influencing parameters of the receiver antenna system in a received-frequency-dependent manner. The individual antennae of the receiver antenna system according to the invention are therefore designed by optimizing the current-influencing parameters of the receiver antenna system – frequency-dependent electrical antenna height (impedance elements on the radiators), antenna diameter, antenna spacing distances and input impedance of the active base-point electronics – in order to minimise the electromagnetic couplings of the individual antennae.

In this context, particular attention is paid to the arrangement of impedance elements within an individual antenna and also to the arrangement of the impedance elements between the individual antennae, which determine the respective, electrically-active antenna height of the individual antenna in a reception-frequency-dependent manner.

Additionally, through appropriate dimensioning of the input impedances of the individual base-point electronics, also outside the useful frequency range of the respective individual antenna, a targeted influence on the electromagnetic couplings between the individual antennae and an optimization of the efficiency of the overall arrangement is achieved.

The active individual antennae optimized in this manner are connected via phase matching networks for phase matching of the transmission signals received in

the individual antennae with a frequency crossover network for combining the individual phase-matched received signals.

The embodiment of the receiver antenna system with several active individual antennae is explained in greater detail below with reference to the drawings. The drawings are as follows:

Figure 1 shows a three-dimensional view of the receiver antenna system according to the invention;

Figure 2 shows in outline an arrangement of the receiver antenna system according to the invention;

Figure 3 shows a plan view of the geometry of the passive antenna region of the receiver antenna system according to the invention and

Figure 4 shows an electrical, block circuit diagram of the receiver antenna system according to the invention.

The receiver antenna system according to the invention as shown in Figure 1 and Figure 2 consists of several individual antennae $2_1, 2_2, \ldots, 2_N$, in the minimal configuration, two individual antennae 2_1 and 2_2. These individual antennae $2_1, 2_2, \ldots, 2_N$ are attached to a printed circuit board 3 as printed conductors. The antenna receiver system 1 has an extension 4 for the individual antenna with the largest mechanical antenna height, which receives the long-wave transmission signal. For protection, the

printed-circuit board 3 with the individual antennae $2_1, 2_2, \ldots, 2_N$ is enclosed within a synthetic-material tube.

Each individual antenna $2_1, 2_2, \ldots, 2_N$, has respectively a mechanical antenna height $L_1, L_2, \ldots, L_N$ and an antenna diameter $d_1, d_2, \ldots, d_N$. The individual antennae $2_1, 2_2, \ldots, 2_N$, each provide several printed-conductor portions $l_{\mu,\nu}$, which are connected to one another via impedance elements $Z_{\mu,\nu}$. For example, the individual antenna 2_1 in Figure 2 provides printed-conductor portions $1_{1,1}, 1_{1,2}, \ldots, 1_{1,m-1}, 1_{1,m}$ and $1_{1,m+1}$, and the intermittent impedance elements $Z_{1,1}, \ldots, Z_{1,m-1}$ and $Z_{1,m}$, while the individual antenna 2_N consists of the printed-conductor portions $1_{N,1}, 1_{N,2}, \ldots, 1_{N,n-2}, 1_{N,n-1}, 1_{N,n}$, and $1_{N,n+1}$, and the intermittent impedance elements $Z_{N,1}, \ldots, Z_{N,n-2}, Z_{N,n-1}$ and $Z_{N,n}$.

The individual impedance elements $Z_{\mu,\nu}$ consist of a circuit, which provides a very low impedance value with low received frequencies, and which, in the ideal case of a received frequency converging towards zero, short circuits the two adjacent printed-conductor portions $l_{\mu,\nu}$ and $l_{\mu,\nu+1}$. By contrast, with high received frequencies, the circuit provides a high real component of the impedance, which, in the ideal case of an infinitely high received frequency, as a pure resistor, suppresses the current flow between the adjacent printed-conductor portions $l_{\mu,\nu}$ and $l_{\mu,\nu+1}$ and therefore reduces the electrically-active antenna height of the individual antenna 2_μ. In this manner, it is possible, through corresponding parametrization of all impedance elements $Z_{\mu,\nu}$ associated with the respective individual antenna 2_μ and their positioning on the individual antenna 2_μ, to adjust the electrically-active antenna height of the respective individual antenna 2_μ to the optimum antenna height for the respective frequency range of the individual antenna 2_μ. In order to realize a frequency-dependent

impedance characteristic of this kind, the individual impedance elements $Z_{\mu,\nu}$ are realised, for example, in a known manner, by a parallel circuit with an inductance $L_{\mu,\nu}$ and an ohmic resistor $R_{\mu,\nu}$. These impedance elements $Z_{\mu,\nu}$ can be distributed on the individual antennae $2_1, 2_2,\ldots, 2_N$ either in a discrete manner or continuously as correspondingly-formed printed conductors.

The respective individual antennae 2_μ and 2_ν are arranged on the printed-circuit board 3 with a spacing distance of $D_{\mu,\nu}$, which is typically a few centimeters. The respective base-points $5_1, 5_2,\ldots, 5_N$ of the respective passive antenna regions $6_1, 6_2,\ldots, 6_N$ of the individual antennae $2_1, 2_2,\ldots, 2_N$ are electrically coupled to the active base-point electronics $7_1, 7_2,\ldots, 7_N$, for example, amplifier elements and/or impedance converters. The passive antenna regions $6_1, 6_2,\ldots, 6_N$ can be designed in all radiator structures, such as monopoles, dipoles etc.

Impedance conversion, amplification and coarse filtering – through the frequency response of the respective individual antenna – of the transmission signals received respectively in the passive antenna regions $6_1, 6_2,\ldots, 6_N$ of the individual antennae $2_1, 2_2,\ldots, 2_N$, are implemented in the base-point electronics $7_1, 7_2,\ldots, 7_N$.

After their impedance conversion, amplification and filtering in the respective base-point electronics $7_1, 7_2,\ldots, 7_N$, the received transmission signals are phase-matched in the subsequent phase matching networks $8_1, 8_2,\ldots, 8_N$, especially in the overlapping range of the filters of the frequency crossover network of the individual adjacent or overlapping received frequency ranges, in order to guarantee an addition instead of a subtraction of the individual received transmission signals. The phase

matching in the individual phase matching networks $8_1, 8_2, \ldots, 8_N$ is optimized to such an extent that the maximum possible phase deviation of two received transmission signals is 90°.

After the phase matching in the phase matching networks $8_1, 8_2, \ldots, 8_N$, a band limitation and combination of the individual transmission signals received in the individual antennae $2_1, 2_2, \ldots, 2_N$ to form a single overall received signal, which provides an overall reception bandwidth, which corresponds to the sum of all of the individual partial received frequency ranges of the individual antennae $2_1, 2_2, \ldots, 2_N$, takes place in the subsequent frequency crossover network 9.

In Figure 3, in order to visualise the geometric antenna optimization, a portion of the two passive antenna regions 6_1 and 6_2 printed on a printed-circuit board 3 of the individual antennae 2_1 and 2_2 of the minimal configuration of a receiver antenna system 1 is illustrated for a lower and an upper partial received frequency range respectively. They consist in each case of the printed-conductor portions $1_{1,1}$, $1_{1,2}$, and $1_{1,3}$ and $1_{2,1}$, $1_{2,2}$, $1_{2,3}$, $1_{2,4}$, $1_{2,5}$, $1_{2,6}$, $1_{2,7}$, $1_{2,8}$ etc. and the intermittent impedance elements $Z_{1,1}$, and $Z_{1,2}$, and $Z_{2,1}$, $Z_{2,2}$, $Z_{2,3}$, $Z_{2,4}$, $Z_{2,5}$, $Z_{2,6}$, $Z_{2,7}$, etc., which are shown in Figure 3 not in their concrete interconnection but as free space relative to their positioning. The optimization of the passive antenna regions 6_1 and 6_2 of the individual antennae 2_1 and 2_2 in order to minimize the electromagnetic couplings takes place through an optimum design of the antenna diameters d_1 and d_2, the spacing distance $D_{1,2}$ between the two individual antennae 2_1 and 2_2, the position of the individual impedance elements $Z_{\mu,\nu}$ relative to one another within the respective individual antennae 2_1 and 2_2 and between the two individual antennae 2_1 and 2_2.

It is evident from Figure 3 that, according to the invention, with a larger spacing distance relative to the base-points 5_1 and 5_2, the printed-conductor portions $l_{\mu,\nu}$ are increasingly shorter in length. Moreover, it is evident that the length L_1 of the individual antenna 2_1 for the reception of relatively high-frequency transmission signals is designed to be shorter than the length L_2 of the individual antenna 2_2 for the reception of low-frequency transmission signals. Finally, the antenna diameter d_1 of the individual antenna 2_1 for the reception of relatively higher-frequency transmission signals is designed according to the invention to be significantly greater than the antenna diameter d_2 of the individual antenna 2_2 for the reception of relatively low-frequency transmission signals.

In Figure 4, in order to visualise the electrical optimization, the minimum configuration of the individual antennae from Figure 3 is presented with the individual antenna 2_1 for the reception of high-frequency transmission signals and the individual antenna 2_2 for the reception of relatively low-frequency transmission signals. According to the invention, the input impedance of the base-point electronics 7_1 of the individual antenna 2_1, which provides a shorter antenna height for reception in the upper frequency range, has a lower value with lower received frequencies. In this manner, low-frequency currents in the individual antenna 2_1 are conducted with low resistance to earth at the input of the base-point electronic 7_1, so that the low-frequency currents coupled from the individual antenna 2_2 to the individual antenna 2_1 do not generate unnecessary losses in the input impedance 10_1 of the base-point electronics 7_1 thereby impairing the efficiency of the antenna 2_2 and do not therefore have a negative influence on the individual antenna 2_2 through electromagnetic

parasitic coupling with the adjacent individual antenna 2_1. In order to realise a small input impedance of the base-point electronics 7_1 with low-frequency received signals, a parallel circuit consisting of an inductance L_{E1} and an ohmic resistor R_{E1} is used as the input impedance 10_1 of the base-point electronics. With higher-frequency received signals, the input impedance 10_1 of the base-point electronics 7_1 provides an input impedance matched to the passive antenna structure.

It is also evident from Figure 4 that the inductances $L_{2,v}$ in the individual impedance elements $Z_{2,v}$ become high-resistance on receiving relatively high-frequency transmission signals, and in combination with the resistors on the individual printed-conductor portions $l_{2,v}$ of the individual antenna 2_2, behave like a ferritized conductor. Accordingly, relatively high-frequency currents on the individual antenna 2_2 are suppressed. As a result, there is no coupling with the adjacent individual antenna 2_1. With low-frequency received signals, the inductances $L_{2,v}$ of the impedance elements $Z_{2,v}$ of the individual antenna 2_2 are of low resistance and do not lead to a suppression of the currents on the individual printed-conductor portions $l_{2,v}$ of the individual antenna 2_2. In the overall operating-frequency range, the input impedance 10_2 of the base-point electronic 7_2 provides a high-resistance, capacitive input impedance. The input impedance 10_2 consists of a parallel circuit with a high-resistance resistor R_{E2} and a capacitor C_{E2} with very small capacity.

In general, it can be stated that all of the impedance elements $Z_{1,v}$ in the individual antenna 2_1 and all of the impedance elements $Z_{2,v}$ in the individual antenna 2_2 not only perform the function of the frequency-dependent electrical shortening of the respective antenna height, but, by variation of their impedance $Z_{1,v}$ on the

individual antenna 2_1, influence the current I_1 in the individual antenna 2_1 in a targeted, frequency-dependent manner, and, by variation of their impedance $Z_{2,v}$ on the individual antenna 2_2, influence the current I_2 on the individual antenna 2_2 in a targeted, frequency-dependent manner, and accordingly also minimize the extent of coupling between the two individual antennae 2_1 and 2_2 in a targeted manner.

Alongside the above-named designs, the input impedances 10_1, 10_2,..., 10_N of the base-point electronics 7_1, 7_2,..., 7_N are additionally mismatched relative to the base-point impedance of the respective passive antenna regions 6_1, 6_2,..., 6_N of the individual antennae 2_1, 2_2,..., 2_N preferably outside the useful frequency range of the individual antenna. In this manner, targeted reflections occur at the inputs of the base-point electronics 7_1, 7_2,..., 7_N, which have the overall effect of minimizing the electromagnetic couplings between the individual antennae 2_1, 2_2,..., 2_N.

The invention is not limited to the embodiment presented. In particular, the invention also covers different antenna geometries, different interconnections of the impedance elements and different input interconnections of the base-point electronics.